Ecophysiological potential of the dão terroir for the production of Touriga nacional red grapes

Vanda PEDROSO[1], João GOUVEIA[2*], Pedro RODRIGUES[2], Isabel ALVES[3], Carlos M. LOPES[3]

1. DRAPC/ Centro de Estudos Vitivinícolas do Dão, Quinta da Cale, 3520-090 Nelas, Portugal.
2. Escola Superior Agrária de Viseu, Quinta da Alagoa, Ranhados, 3500-606 Viseu, Portugal.
3. Instituto Superior de Agronomia, Tapada da Ajuda, 1349-017 Lisboa, Portugal
*Corresp. Author: João Paulo Gouveia, Telephone +351232480600, Email: gouveia.viti@gmail.com

ABSTRACT
Aiming to evaluate the potential of the portuguese Dão winegrowing region for the production of Touriga Nacional (TN) red grapes, climatic, ecophysiological and viticultural data from two different climatic years (2004, wet year and 2005, dry year) are presented and discussed. The data was collected in the control non-irrigated plants of an irrigation experiment installed at the Dão Research Station, Nelas, Portugal. The vineyard is established in a typical granitic soil and trained on a vertical shoot positioning. According to the Géoviticulture Multicriteria Climatic Classification System, the Dão region is classified as temperate/temperate warm for the heliothermal index, with cool nights (night cold index) and moderately dry (dryness index). In 2004 the predawn leaf water potential presented always values higher than -0.2 MPa from flowering to harvest but in 2005 moderate to severe water stress was observed during the ripening period (-0.4 MPa at veraison to -0.6 MPa at harvest). Leaf stomatal conductance and photosynthetic rate displayed a decreasing pattern from flowering to harvest in both years but attained much lower values in the 2005 ripening period as compared to that of 2004. The yield was similar in both years but 2005 showed lower sugar content, similar titratable acidity and a higher anthocyanin berry skin content. Our data shows that the Dão terroir presents a high inter-annual climate variability which has important repercussions on TN responses being the most unfavorable climatic years those were the high temperatures are coincident with water stress during the first half of the ripening period. In those years irrigation should be applied in order to obtain better quality grapes.

Keywords: Dão, grapevine, Touriga Nacional, bioclimatic indices.

1 INTRODUCTION

The Dão winegrowing region is located in the Center-North of Portugal and presents a mesothermic climate, with a warm and dry summer and a cold and rainy winter. The yearly average rainfall is 1100 mm but only a small fraction (8%) falls during the summer. The vineyards are traditionally non-irrigated but, as most part of the soils are granitic derived with low water retention capacity, in dry years it is common to observe symptoms of water stress mainly from the beginning of the ripening period. Under those circumstances the vines are prone to early leaf senescence and burn as they are not able to maintain leaf temperature by transpiration. If the defoliation is too early and severe the reduction of the photosynthetic surface and photosynthetic rates of the remaining leaves may induce a ripening blockage and consequent inadequate or incomplete ripening [1]. The resulting increase in cluster exposure can also cause berry sunburn and/or negative effects on yield and berry composition. Moreover, as the Dão region has very hot summers, the high temperature that the exposed berries can reach may also negatively affect the anthocyanins content either by inhibiting the synthesis and/or by promoting their degradation or, more common, for both reasons [2, 3].
Touriga Nacional (TN) is a native variety from the north of the country recognized by its capability of producing high quality Port and table red wines with a high ageing potential. TN is a vigorous variety with downward shoot growth, is highly susceptible to poor fruit set and, in water stress conditions, is prone to the loss of leaves around the fruit-zone [4]. This work aims to assess the effects of two contrasting climatic seasons (wet and dry) on TN physiology, vegetative growth, yield and berry composition in order to evaluate the ecophysiological potential of the Dão terroir for TN quality wines.

2 MATERIAL AND METHODS

This work took place at the Dão Grape and Wine Research Center, Nelas (Latitude 40° 31' N, Longitude 7° 51' W, Elevation 440 m), in a vineyard planted in 1989 with the red grape variety TN grafted on SO4 rootstocks. The soil is from granitic origin, with a coarse texture and acid pH, low organic matter content medium content of phosphorus, high content in potassium and a low water retention capacity. The data analyzed in this paper was collected in the control non-irrigated plants of an irrigation experiment (for more details of the experiment see [7]). The vines were spaced 1.1 m within and 2.5 m between rows, trained on a vertical shoot positioning with two pairs of movable wires and pruned on a double Guyot system. All vines were uniformly pruned to 14 nodes per vine.
Meteorological variables were measured at an automatic weather station installed at the experimental plot. For each season the following bioclimatic indices were calculated: BEDD (Biologically Effective Degree-days) [5], Huglin index (HI), Cool Night index (CI) and Dryness index (DI) [6]. Predawn leaf water potential (ψ_{pd}) and photosynthetic rate (A) were periodically measured on clear and sunny days on 8 to 12 fully mature and well-exposed leaves using a

pressure chamber and a portable IRGA (LCA-4, ADC) respectively.The yield was monitored by recording the number of clusters and their total weight from 12 vines per elemental unit (48 vines/treatment). At harvest berry composition was evaluated through the sampling of 100 berries per elemental plot. At winter, shoot number and fresh pruning weight per vine were also recorded.

3 RESULTS

3.1 Climate

In 2004, while June showed the highest air temperature, August presented a monthly average temperature 2-3°C lower than the 10 years average. The 2003/2004 hydrological year was, overall, a dry year. The amount of rainfall was only 846.9 mm, a value near the lowest value recorded in the period 1959-1988. In October and November 2003 the rainfall was above the average for the region and in the first semester of 2004 it was only 43% of the average. The August 2004, which corresponds to the first half of the ripening period, presented a very high rainfall (106.8 mm) for the period.

Regarding the 2005 season, the June and August temperature were above the mean value for the region. During July and August it was recorded 11 days with temperatures above 35ºC and 4 days with a reference evapotranspiration higher than 8 mm/day. The hydrological year 2004/2005 was also a quite dry year with a very uneven distribution of rainfall. Of the 616 mm yearly recorded rainfall about 50% (306 mm) occurred in October 2004.

Using weather data from the period 2000-2010, several bioclimatic indices were calculated (Table 1). According to the Géoviticulture Multicriteria Climatic Classification System [6], the Dão region is classified as temperate/temperate warm with cool nights during the ripening period and moderately dry. Regarding the comparison of the two seasons we can observe that 2004 has a lower HI and BEDD, a higher CI and a less negative DI. The seasonal evolution of the soil water storage estimated in DI formula (data not showed) shows that the difference in the Dryness Index between seasons were caused mainly by the abnormal high rainfall occurred during August 2004.

Table 1. Bioclimatic indices calculated for Nelas, Portugal.

Period/season	HI	BEDD	CI	DI
2000-2010	2148±50,9	1457±22,7	13,1±0,25	-37,9±13,6
Classification GMCC*	HI_{+1}		CI_{+1}	DI_{+1}
2004	2118	1426	13,5	-32,8
Classification GMCC*	HI_{+1}		CI_{+1}	DI_{+1}
2005	2287	1505	12,7	-93,9
Classification GMCC*	HI_{+1}		CI_{+1}	DI_{+1}

HI, Huglin Index; BEDD, biologically effective degree-days; CI, Cool night index and DI, Dryness index**.** *Multicriteria Climatic Classification System [6].

3.2 Vine physiology

While in 2004 the predawn leaf water potential (Y_{pd}) remained between -0.1 and –0.2 MPa throughout all the growing season, in 2005 Y_{pd} decreased from June onwards, reaching mean values of –0.6 MPa at the middle of September (Fig. 1). Photosynthetic rate (*A*) displayed a decreasing pattern from flowering to harvest in both years but attained much lower values in the 2005 ripening period as compared to that of 2004 (Fig.1). Stomatal conductance pattern was parallel to *A* and, in general, the relative differences between seasons mirrored those reported for *A* (data not showed [7]).

3.3 Vegetative growth, yield and berry composition

The relative comparisons of the vegetative growth, yield and berry composition between the two seasons are presented in figure 2 where 2005 data is showed as a percentage of 2004. The lower water availability observed in 2005 induced a loss of leaves around the fruit-zone and a consequent higher cluster exposure (data not showed, [7]). 2005 presented a 10% reduction in the pruning weight differences that are explained by the lower shoot weight as compared to 2004 (Fig. 2).

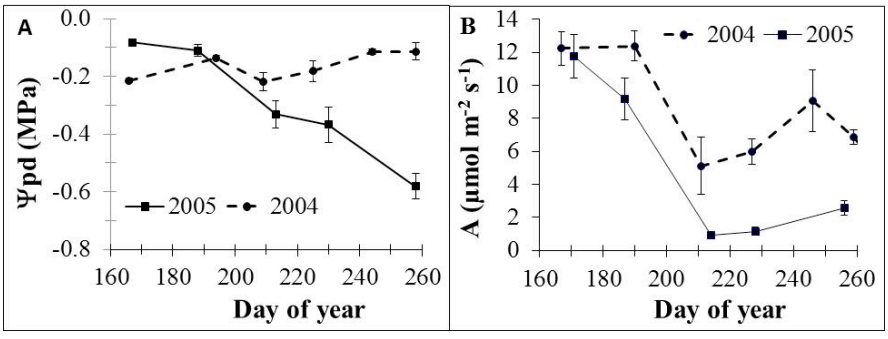

Figure 1. Seasonal pattern of predawn leaf water potential (A) and photosynthetic rate (B) during the growing seasons of 2004 (veraison at day 229) and 2005 (veraison at day 222). Data are shown as mean ± s.e.

2005 presented a 12% higher flower number per inflorescence but, as the % fruit set was similar to 2004, berry number per cluster was also higher in 2005 (108 *vs* 118.5 in 2004 and 2005 respectively). Despite the absence of water stress in 2004 the cluster weight was lower than in 2005 (-14%) differences that are explained either by the 10% lower berry number and the much higher botrytis bunch rot incidence observed in 2004 (40% *vs* 5% respectively in 2004 and 2005) (Fig.2).

Regarding berry composition, 2005 season presented a 15% lower Brix (24.4 *vs* 20.9 respectively in 2004 and 2005), a 7% lower titratable acidity, similar pH and a higher skin anthocyanins content (597 *vs* 1235 mg/L respectively in 2004 and 2005) (Fig. 2).

4 DISCUSSION AND CONCLUSIONS

Our data shows that the climate variability observed in these two contrasting climate seasons had important consequences on the performance of TN. In the dry season of 2005, the high temperatures and the water stress during the first half of the ripening period have induced a delay of the sugar accumulation as a consequence of a source limitation caused either by the basal leaf senescence and the stomatal closure of the remaining leaves. However the higher skin anthocyanin obtained in 2005, as compared to 2004, suggest a positive effect caused by the natural defoliation on cluster exposure [2,3]. In dry seasons, in order to avoid a severe water stress, deficit irrigation should be applied. However, as in the Dão winegrowing region most part of the vineyards are non-irrigated, other strategies should be envisaged as, e.g. the use of more drought resistant rootstocks.

In the case of the 2004 growing season, the high rainfall occurred during August allowed to avoid the water stress and, consequently, induced higher photosynthetic rates and higher berry sugar content. However, the wetter ripening period induced a higher botrytis bunch rot incidence and consequent negative effects on yield and berry composition.

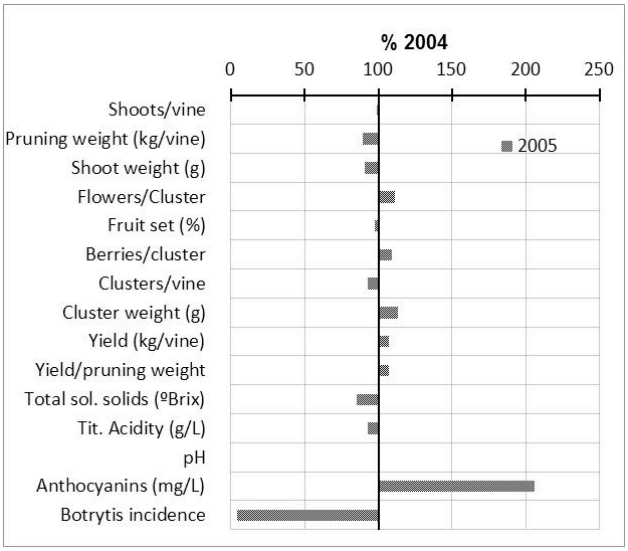

Figure 2. Effect of contrasting climate seasons on vegetative growth, yield and berry composition of Touriga Nacional at the Dão winegrowing region. 2005 data expressed as % of 2004.

As a conclusion we can say that the Dão winegrowing region is a terroir with high viticulture potential but it's high inter-annual climate variability might have important repercussions on Touriga Nacional behavior mainly in what concerns berry health and composition.

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